SCOTTISH PLANT BREEDING STATION

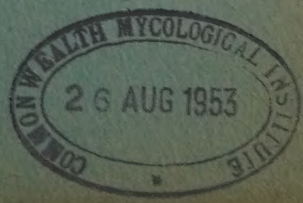
CRAIGS HOUSE, CORSTORPHINE

EDINBURGH

ANNUAL REPORT

(ABRIDGED)

1953



REPORT

(ABRIDGED)

TO THE

ANNUAL GENERAL MEETING

23rd JULY 1953

BY THE

BOARD OF DIRECTORS

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ESTABLISHMENT FOR 1953-54

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1952

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1953

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STAFF

Scottish Plant Breeding Station

Director	J. W. Gregor, Ph.D., D.Sc., F.L.S.
Chief Assistant	W. Black, Ph.D., D.Sc., F.R.S.E.
Cereals	D. Cameron, B.Sc. H. D. Garvin, B.Sc.
Herbage Plants and Genecology	J. W. Gregor. Miss P. J. Watson, M.A., Ph.D. D. J. Harberd, M.Sc. D. A. Wilkins, B.Sc.
Potatoes—	
Breeding	W. Black. J. M. Dunnett, B.Sc.
Virus Disease Investigations	G. Cockerham, B.Sc., Ph.D. Miss T. M. R. M'Ghee, B.Sc., N.D.D. A. W. Macarthur, B.Sc.
Root Crops	V. M'M. Davey, B.Sc., Ph.D. F. J. W. England, B.Sc.
Sugar Beet	V. M'M. Davey. F. J. W. England.
Laboratory Assistants	A. McFarlane. W. Brown.
Secretary	R. J. L. Gallie.
Assistant Secretary	Miss A. Malcolm.
Clerical Officer	Mrs H. H. Gray.
Shorthand Typist	Miss R. Jackson.

Distribution of Membership as at 31st March 1953

Aberdeen	19	Fife	32	Perth	22
Angus	34	Inverness	4	Renfrew	4
Argyll	2	Kincardine	2	Ross and Cromarty	12
Ayr	18	Kinross	3	Roxburgh	14
Banff	2	Kirkcudbright	3	Selkirk	2
Berwick	36	Lanark	29	Stirling	8
Bute	1	Linlithgow	12	Sutherland	2
Caithness	8	Midlothian	107	Wigtown	6
Clackmannan	2	Moray	10	England	35
Dunbarton	4	Nairn	1	Ireland	3
Dumfries	11	Orkney	3	Abroad	6
East Lothian	72	Peebles	4		
		Total	533		

List of Members elected since 31st March 1952

CRUICKSHANK, G. A., M.A., B.Sc.(Agr.) (Scottish Agricultural Industries, Ltd.), 35 Charlotte Street, Leith, Edinburgh.
ELLIS, JOHN, Crookmore, Alford.
ENGLAND, H. T. PETER (Richard England, Ltd.), West Dock, Cardiff.
FARQUHARSON, JOHN, Gowanbank, Fyvie.
MELVILLE, HARRY W., Balmullo House, Leuchars.
MILLER, DAVID, Moatmill, Tealing, by Dundee.
PITKEATHLY, D. S. (Quaker Oats, Ltd.), Whitehaven, Cumberland.
SEED, JOHN F., Woodend, Duns.
YOUNG, E. (Dunns Farm Seeds, Ltd.), Dunnseed Chambers, Salisbury, Wilts.

ADMINISTRATION

Membership

At 31st March 1953 the total membership was 533, comprising 194 life members and 339 annual members. Six new members were elected during the year, while 16 members died or resigned.

Obituaries

The Society lost the services of one of its Directors through the death of Mr W. A. Smith, M.B.E., M.A., B.Sc., on 26th August 1952. Since his election to the Board of Directors in 1949, Mr Smith, through his membership of the Research, Management and Finance Committees, gave active and valued service. The Directors wish to record their appreciation of his interest in the affairs of the Society.

Staff Changes

Mr D. J. Harberd, M.Sc., and Mr D. A. Wilkins, B.Sc., were appointed on 1st October 1952 to fill the posts of Genecologist and Plant Sociologist respectively.

Mr J. M. Dunnett, B.Sc., was appointed on 1st July 1953 to assist in breeding for resistance to potato eelworm.

Seafield

Considerable progress has been made during the year in the construction of new buildings. Two workers' cottages, otherwise complete, lack only connection to sewage and other services. The Department of Agriculture for Scotland has agreed to the erection of five other cottages for workers in the community on a site yet to be chosen, thus restoring the original estimate of accommodation required. Almost all

greenhouses have been erected and are in process of fitting out. The main laboratory block and out-buildings have reached a stage of construction in keeping with the estimated rate of progress.

Suitable terms for the occupation of land on the Bush Estate have been the subject of negotiations with the Edinburgh Centre of Rural Economy. The Directors have given careful consideration to the effect the transfer to Seafield will have upon the security of the Society's position, since, although approximately four-fifths of the cost of establishing the new station will be met by Government funds, the Society's contribution of the remainder will absorb almost the whole of its invested funds. Accordingly it was considered desirable to seek a feu of the whole of the land at Seafield. Unfortunately, the Edinburgh Centre of Rural Economy were agreeable to a feu charter being granted only for the land upon which buildings will be erected and to the remaining area, used for experimental plots, being subject to an Agreement largely in their favour.

Although the terms of the Agreement, which allow control of the experimental land to remain in the hands of the Edinburgh Centre of Rural Economy, might appear to jeopardise the research programme, which will utilise the whole of the available area, the Directors felt bound to acknowledge the co-operative nature of the Edinburgh Centre of Rural Economy, and to accept the terms. The Edinburgh Centre of Rural Economy for its part recognises in a " back letter " the special use to which the land is put and the need for appropriate consideration being given to the Society in the event of any change affecting the area.

Experimental Centres

Peeblesshire

Stocks of virus-free potatoes—

at the farm of Mr William Mitchell, West Loch, Eddleston.

Inverness-shire

Oat material for selection—

at the farm of Mr C. Mackintosh, Easter Duthil, Carrbridge ; and in

Argyll

at the farm of Mr H. Mackay, Kintraw Farm, Barbreck.

MULTIPLICATION AND MARKETING OF PLANT BREEDING STATION PRODUCTS

In accordance with the Agency arrangements set out in the 1952 Annual Report, elite stocks of Plant Breeding Station products have been handed over for further multiplication and marketing to official Agents as follows :—

Oats	Bell	Messrs Macfarlan, Shearer & Co., Greenock.
	Albyn Donside Craigs Afterlea	Scottish Agricultural Industries, Ltd., 35 Charlotte Street, Leith.
	Early Miller	Mr George Clapperton, Sheriffhall Mains, Dalkeith.
Beans	Albyn Tick	Messrs Roughead & Park, Ltd., Haddington.
Grasses	Scotia Cocksfoot Scotia Timothy	Messrs David Bell, Ltd., 15 Coburg Street, Leith.
Potatoes	Pentland Ace	Messrs W. J. Campbell & Miller, Ltd., 2 Charlotte Square, Edinburgh.
	Craigs Alliance	Messrs J. C. Dougal, Ltd., Auchterarder.

The Directors have decided it is impracticable to require Agents handling Station varieties to give priority in distribution to members of the Society and have accordingly cancelled this provision in Agents' agreements. Intimations regarding new Plant Breeding Station productions will appear in the Society's Annual Reports, and members wishing stocks are requested to take advantage of such advance information and to make early application to the Agents.

Finlayson Gold Medal

The Trustees of the Finlayson Bequest awarded to the Society the 1951 "Finlayson Gold Medal" for the potato variety "Pentland Ace."

CERTIFICATION OF "SCOTIA" STRAINS OF GRASSES

Since the multiplication of stock-seed is exclusively in the hands of the Society's Agents, stock-seed certificates may only be issued for the Agents' crops.

A certificate will also be issued in respect of seed crops sown with stock-seed. Crops entered for certification will be field-inspected on behalf of the Society by the National Institute of Agricultural Botany, Cambridge. Forms of application for inspection of seed crops may be had from the Secretary, Scottish Plant Breeding Station, Craigs House, Corstorphine, Edinburgh 12, and completed forms should be returned as early in the season as possible, but, in any case, not later than 30th April. Samples of the cleaned seed from field-recommended crops should be sent to the Secretary, Scottish Plant Breeding Station, Craigs House, Corstorphine, Edinburgh 12, who will arrange to have them tested by the Seed Testing Station, Corstorphine, Edinburgh. A charge will be made for field inspection and seed testing.

Pre-inspection of Fields.—The greatest importance is laid on the adequate isolation of fields and their freedom from weeds. A seed field should not adjoin fields in which other strains of the same species will be allowed to come into head; at least two hundred yards should separate the seed crops from such fields. Whenever possible fields should be inspected before ploughing.

Pre-inspection of fields by the National Institute of Agricultural Botany can be arranged either through the Scottish Plant Breeding Station or direct with the National Institute of Agricultural Botany.

TABLE I.

DATA FROM 1952 REPLICATED OAT TRIAL

VARIETIES IN HEIGHT-MATURITY CLASSES IN ORDER OF GRAIN YIELD IN EACH CLASS

Identification Letter	Name of Variety or Station No. of Hybrid Selection	Estimated Yield of Dressed Grain per Acre in Cwt.	Estimated Yield of Straw per Acre in Cwt.	Average Plant Height in Inches	Days to Mature
Early Short					
AV	Yielder	33.2	35.6	43.5	140.5
CO		32.7	52.9	39.8	134.5
CR		32.0	45.8	42.0	139.5
CQ		31.5	42.7	39.0	137.0
CN		31.5	44.2	38.3	134.5
CP		30.1	49.7	40.5	134.5
Early Medium					
CZ		31.1	38.4	45.8	135.8
CY		28.2	41.7	48.8	139.5
BU		26.2	51.4	48.0	139.5
BW		26.1	42.8	48.0	139.5
BY		25.7	48.9	48.0	140.5
BV		24.8	46.7	48.8	140.0
Early Long					
DA	*Aa* 734	29.8	44.4	51.8	138.0
Mid-Season Medium					
CT	*Aa* A18	38.4	40.4	47.3	141.5
CF		37.2	41.5	44.3	144.5
AX	Star	36.4	39.2	46.5	143.0
CE		36.4	37.8	44.3	142.5
BQ		36.0	39.2	45.0	145.0
CG		35.4	38.6	44.3	144.5
DF	*Aa* 712	35.1	46.3	48.0	141.0
CD		33.4	36.8	43.5	142.5
CJ		32.5	48.1	48.8	142.5
BR		32.1	35.3	45.0	144.5
CL		30.3	50.5	48.8	142.5
BM		28.9	46.9	47.3	144.5
CW		28.2	38.6	49.5	144.5
CV		27.9	39.0	48.8	145.0
BX		25.3	37.9	46.5	141.5
CM		27.3	44.5	47.3	141.5
Mid-Season Long					
BK	*Aa* 733	29.7	44.3	52.5	141.0
BB	Bell	27.9	46.1	52.5	141.5
Late Medium					
AY	Sun II.	38.3	48.2	47.3	147.5
CC		36.0	43.2	47.3	149.5
CK		35.9	41.7	48.8	147.5
BO		34.2	38.1	43.5	147.5
AW	Onward	34.1	41.9	48.8	149.5
BS		33.0	32.5	44.3	146.5
BP		33.0	32.2	45.0	147.5
CT		32.9	41.2	49.5	148.5
DE	*Aa* 735	32.2	42.2	48.8	146.5
CB		31.4	50.3	49.5	150.5
CH		30.3	39.1	48.0	147.5
CA		29.8	36.3	45.8	150.5
CX		27.7	38.5	48.0	146.5
Late Long					
BZ		29.1	53.4	57.0	151.5
DB		27.4	38.5	52.5	148.5
BN		20.8	43.9	52.0	149.5
Differences for Significance	5 per cent	5.6	8.3		
	1 per cent	7.2	10.9		

RESEARCH PROGRAMME

Cereals

Oats

The period of this Report covers the 1952 harvest and the spring sowing of 1953. As in the past, the selection of breeding material was continued with the object of combining those characteristics thought to be most suitable for the upland and high rainfall areas in Scotland. In addition to recording data for times of maturity, plant yield, appearance, strength of straw, &c., the selections made in 1952 have all been recorded for weight of grain per ear with the object of examining to what extent ultimate yield per acre could be predicted from this data. Much of the breeding material grown in 1952 is now regarded as fixed and over one hundred different lines were selected and are being multiplied for inclusion in future replicated trials.

The 1952 replicated trial carried out at the Station, which consisted of forty-nine varieties arranged in a 7×7 lattice square of four replications and which contained forty-four unnamed Station selections and five control varieties, was harvested in good condition, and, as in the past, data were obtained relating to maturity, height, grain and straw yields, &c. The most promising of these varieties have been included in the 1953 trial and two of the delayed germination series have been given the numbers *Aa* 734 and *Aa* 735 and distributed for regional trial. As shown in Table I., the polyploid oat, *Aa* A18, which in 1951 outyielded all the other varieties in the trial, has again headed the list for grain yield, outyielding Sun II. by 0.1 cwt., Star by 2 cwt., Onward by 4.3 cwt., and Yielder by 5.2 cwt. These differences are not significant. Eight varieties in the trial had a higher yield of straw than Sun II. (48.2 cwt.), the highest of the control varieties. The other controls were Bell (46.1 cwt.), Onward (41.9 cwt.), Star (39.2 cwt.), and Yielder (35.6 cwt.). The polyploid *Aa* A18 gave 40.4 cwt.

During the season soil fertility differences were apparent within the trial area and some of the plots were affected by eelworm, which resulted in a large experimental error. It

appeared, however, that varieties differed in their response to these differences, particularly in regard to the proportion of grain to straw, and it was decided that this differential response of varieties to changes in soil fertility should be further examined. The 1953 trial, therefore, has been laid out as a 5×5 lattice square with three replications, each plot being subdivided, the sub-plots receiving one and two levels of nitrogen respectively. The twenty-five varieties include a number of those which have already been distributed for regional trial and concerning which a certain amount of information is available.

It has long been felt that the selection of material on the basis of its performance at Corstorphine alone was likely to result in the loss of lines of value in other districts of Scotland. During the period under review discussions with the North of Scotland and West of Scotland Colleges concerning ways of ensuring that the best possible use was made of material bred at the Plant Breeding Station for problem areas of Scotland, resulted in the establishment in the spring of 1953 of two selection centres, one in the North of Scotland area at Easter Duthil, Carrbridge, Inverness-shire, and the other in the West of Scotland area at Kintraw, Barbreck, Argyll. One hundred and twenty-eight selections of unfixed F3 and F4 generation hybrids have been lined out at each centre with a view to selecting at an early stage those types which best suit the prevailing environments. In addition, a replicated trial of ten varieties, including four normally grown in the district, has been sown at each centre : the varieties chosen being those whose characteristics appear most suitable for each environment. The indebtedness of the Cereal Section to the regional staffs of the two colleges and to Messrs Mackintosh and Mackay, who farm Easter Duthil and Kintraw respectively, should be recorded, much help being received both in the selection of suitable sites for the centres and in sowing the plots in the spring.

Facilities similar to those obtained at these two selection centres were offered by the National Institute of Agricultural Botany at Seale Hayne in Devon, for the growing and selection of plant breeders' material. It was felt that this environment did not fit in with the Station's policy of breeding varieties for the less fertile areas in Scotland, and that meanwhile the use of selection centres should be restricted to areas readily access-

ible from the Plant Breeding Station, as it will be necessary to visit these centres throughout the growing season for the purpose of recording data and making selections. Advantage has, however, been taken of this offer to send material to Seale Hayne for a replicated trial of varieties. These include a number of distinct types, some of which are common to those sown in the trials at the Carrbridge and Oban centres, and all of which are included in the 1953 replicated trial at the Plant Breeding Station. The data obtained from this series of trials in widely differing environments will, it is hoped, provide much useful information about varietal behaviour and response to differing conditions.

In addition to supplying material for the trial at Seale Hayne and sowing unfixed and fixed material at the selection centres, attention was again paid to the problems of producing an oat suitable for cultivation on the alkaline soil areas of Scotland. Through the co-operation of the County Organisers in Uist, Tiree and Orkney, unselected bulk plots of a number of oat hybrids bred for this purpose were grown in these areas, and selections were obtained from them. These were examined at the Plant Breeding Station and a number have been returned to the alkaline soil environments for further comparison and selection.

Stocks of the more promising varieties which have been in regional trials in 1952 and previous years were again distributed to the three Agricultural Colleges in Scotland and to the National Institute of Agricultural Botany in England.

Reports from regional trials carried out in the past suggest that of the varieties at present on trial, *Aa* A18 is to be regarded as an early-ripening, high-yielding oat of feeding type, *Aa* 732 as a possible successor to Early Miller, and *Aa* 733 as a possible successor to Bell, resembling them respectively in general characteristics, and being capable of a higher yield of grain. The variety *Aa* 720 has again been favourably commented upon from the more fertile areas of Morayshire and Easter Ross, where on soils which have a satisfactory moisture supply it has proved a high-yielding, stiff-strawed, early-ripening oat whose straw appears to be satisfactory for feeding. *Aa* 730 was tried in 1952 as an arable silage oat and preliminary reports show that it is very satisfactory for this purpose, being a very leafy type. Under normal conditions such as prevail at the Plant Breeding Station, this variety is in the high-yielding

class for grain, and production of seed for arable silage should not be unduly expensive.

The Agency scheme for the marketing of oat varieties produced at the Plant Breeding Station came into force during the year. Two acres each of Early Miller, Craigs Afterlea, and Albyn Donside were grown under contract at Almond Hill, and one and a half acres of Bell were grown at the Plant Breeding Station. The produce of these elite plots has been delivered to the Agents for multiplication and subsequent marketing.

Problems relating to inter-specific hybridisation of oats for the synthesis of new types, and to the experimental production of polyploids by means of colchicine and acenaphthene, have again received attention. Of the induced polyploids mentioned in the last Annual Report, the cross between the induced polyploids *A. strigosa* (4x) and *A. sativa* (12x) to give the octoploid, has been repeated, but while the plants have grown normally, they have again been sterile and no seed has been obtained from them.

Barley

Elite seed of Craigs Triumph barley was disposed of with difficulty and the area of this variety has been reduced to one-third of an acre. Two acres of the unnamed, short, stiff-strawed selection *Ac* 370 have been sown in 1953, as it is a very suitable nurse crop for the Scotia Timothy with which it is undersown. *Ac* 370 has again been distributed for regional trial as a feeding barley in comparison with the stiff-strawed Scandinavian barleys, under heavy nitrogen dressings.

Herbage Plants and Genecology

The need for more production from our land is always present and much has been accomplished in raising yields from rotational grass by careful choice of suitable herbage strains and wise management. It is possible that, apart from the advantages to be gained from the use of strains bred for specific purposes, further substantial increases in yields from the best-farmed grassland are unlikely. The greatest hope

lies rather in the considerable area of marginal land and perhaps even more in the hill land which is so extensive in Scotland.

It is quite obvious that much of the hill land is totally unsuitable for any type of cultivation on account of the high altitude, rocky nature of the ground and general inaccessibility, but even at the lower elevations it is by no means always practicable or advisable to cultivate. Some of the possibilities of fertiliser treatment are discussed elsewhere in this Report and the importance of the individual species is emphasised.

Comparatively little is known about the genetic make-up or pastoral potentialities of the various species which contribute to the natural vegetation of any given area, and it is for this reason and in order to gain some factual information on these points that a study of the British population of *Festuca ovina* or Sheep's Fescue is being carried out. It has been ascertained that two chromosome races exist within the British Isles and that each has a distinct distribution, although it is not possible to distinguish morphologically between the two in the wild. The results of a replicated trial between the populations of known tetraploids and known diploids, however, showed that though there is an overlap in character measurement, the tetraploid is potentially always the bigger plant. Responses to manuring will have to be worked out, but it may be that the tetraploid is the more responsive form and, therefore, a knowledge of its distribution might well prove to be of economic importance. It is more than likely that similar unappreciated internal differences exist in other hill species. More detailed observations on wild species are also being carried out in a replicated trial of four native species occurring together on three different slopes of the Pentlands. In the wild the southern slope is undoubtedly the earliest, but whether there is any genetic difference between the plant populations remains to be investigated.

The genecological studies which were interrupted by the untimely death of Dr Earnshaw have been resumed and considerable attention is being paid to Red Fescue (*Festuca rubra*). It is particularly interesting to note that the octoploid chromosome number has been found to be much more widespread within the British Isles than was originally anticipated. The hexaploid, however, still remains the common plant of pasture land.

There is already some evidence to suggest that such chromo-

some races may be further subdivided into environmentally specialised races. Work dealing with the patterns of ecotypic differentiation in native populations is already in progress, but in the meantime is mainly concerned with a search for experimental material suitable for an examination of some of the factors controlling the distribution of heritable variation in hill-land species. Some species of *Euphrasia* would seem to have possibilities in this direction and accordingly material is being collected for use in preliminary studies.

As indicated above, the specialised strain would seem to have an increasingly important part to play in future arable grassland practice, especially where the practices are themselves highly specialised. It is for this reason that the breeding work is primarily concerned with the production of specialised rather than general-purpose strains. Attention is being paid, for example, to a late-flowering ryegrass of erect habit which might be useful for cutting for silage under conditions of very intensive manuring. A vigorous early cocksfoot has been multiplied and has been accepted for inclusion in the trials conducted by the Plant Registration Station at East Craigs. The progenies of several crosses between plants of Ayrshire perennial ryegrass which showed little or no late-summer or autumn shooting are being tested. The strain of smooth-stalked meadow grass of Oregon origin which was multiplied for trial purposes last year is being grown in a replicated trial and will be compared with the Cambridge GN4 strain.

A new elite stock of Scotia cocksfoot is being multiplied. This strain was initially bred with the emphasis on palatability, and in producing the new stock care has been taken to preserve this characteristic. Its soft leaves are readily eaten by sheep, and on this account when sown in sheep pastures, its intended environment, it shows little tendency to increase in frequency at the expense of the ryegrass.

At the request of the Grassland Committee of the Scottish Agricultural Improvement Council and with the co-operation of Mr I. V. Hunt of the West of Scotland Agricultural College and Messrs James Gray & Co., Ltd., of Stirling, an examination of the variation within the Stirlingshire and the Carse of Gowrie populations of timothy has been undertaken. Samples from these two areas have been sown and in due course a replicated trial will be laid out and an analysis of the material made.

Potatoes

One of the fundamental problems associated with potato breeding for field immunity from the blight fungus, *Phytophthora infestans*, is the determination of the limits of mutability and adaptability of the parasite. In this connection, the examination of isolates of local origin failed to reveal any new forms beyond the four specialised races previously recorded. On the other hand, isolates obtained through the helpful cooperation of scientists in a number of countries overseas proved to be more variable, resulting in the addition of three new strains to the collection and bringing the number of qualitatively distinct strains to thirteen. The three new strains fall into place in the scheme for the classification of strains on a genetical basis, which was formulated on the evidence of the ten strains previously examined.

In the search for possible new genes controlling resistance to blight, a heterogeneous collection of blight-resistant hybrids was tested in 1952. The results showed that all the genes involved were similar to one or other of those already identified in previous years. It is intended to continue and extend these tests as suitable material becomes available.

The breeding work concerned with the recombination of the four known genes was continued in order to make available for selection purposes as many seedlings as possible carrying the full complement. Several such genotypes are now in the more advanced stages of trial as possible economic types, and samples of them have been sent to various parts of Africa for cultivation in districts where the attacks of blight are severe. It is hoped, by this method, to ascertain as quickly as possible whether strains capable of attacking them do exist, or are liable to be evolved.

The experiments concerned with the production of economic types possessing resistance to virus Y have been continued and many high-yielding seedlings have been produced. Much of this material was bred originally from *S. simplicifolium*, but, as a result of repeated hybridisation, several wild species appear in its pedigree. The selections obtained by crossing such derivatives of *S. simplicifolium* with a Y-resistant variety of Australian origin show particular promise as virus Y resisters. Most of the selections also possess one or more of

the genes conferring resistance to blight and some of them are field immune from virus X.

A programme for breeding for resistance to the potato root eelworm (*Heterodera rostochiensis*) has now been established. Selfed seed of the eelworm resistant lines of *S. andigenum* in the Commonwealth Potato Collection was made available for sowing in 1952 and three hundred and seventy-six seedlings were grown in an eelworm-infested plot at Boghall. At harvest-time the majority of the plants appeared to be free from eelworm cysts, although all the control plants were severely affected. From the data which have been obtained it appears that resistance to eelworm attack is a heritable character which may be introduced into economic varieties within a relatively short period of time. Many crosses were made during the flowering season and ample hybrid seed is available for continuation and expansion of the work in 1953.

The Registration Trials in 1952 contained fourteen of the Society's seedlings, of which eight were included in the 1st-Year, five in the 2nd-Year, and one in the 3rd-Year tests. These selections, with one exception, were field immune from all the strains of blight which have been found in the field in this country. Six of them were also field immune from virus X and one showed resistance to virus Y through its localised necrotic reaction to infection with the virus. The Registration Committee recommended that three of the selections in the 1st-Year Trials and two in the 2nd-Year Trials should proceed to the 2nd- and 3rd-Year Trials respectively in 1953. A further six selections have been forwarded for inclusion in the 1st-Year Trials in 1953. In 1952 Pentland Ace, which was registered in 1951, was multiplied on contract in Aberdeenshire, where about three acres were grown. The produce, amounting to over twenty tons, was sold to the Society's Agents, Messrs W. J. Campbell & Miller, Ltd., 2 Charlotte Square, Edinburgh, for further multiplication and marketing.

The virus-tested stock of Craigs Alliance, extending to about one and a quarter acres and grown at Strathallan, was also transferred to the Society's Agents, Messrs J. C. Dougal, Ltd., Auchterarder, for further multiplication and marketing.

Virus-tested stocks of the Society's named varieties and of eleven unnamed selections were grown under healthy conditions at West Loch, Peeblesshire. At this isolated Sub-station,

the growth of the crops was satisfactory, but considerable damage to the plants was caused by crows.

Advantage was also taken of the facilities at West Loch to grow small plots of three hundred and thirty-two blight-resistant selections which had been raised under insect-proof conditions in the glasshouse the previous year. It is hoped, by extending this method of raising seedlings and multiplying the selections under virus-free conditions, to be able to provide healthy tubers for all trial and experimental purposes. At the present time, however, only a small proportion of the seedlings can be raised in this fashion owing to the limited glasshouse accommodation available.

Samples of tubers and seeds were again sent to centres in many different countries overseas for trial and experimental purposes. Some of the selections sent in previous years continue to give good results in commercial cultivation as disease-resistant varieties.

In continuation of studies on virus X a further selection of strains was compared in their effects on potato varieties. The majority of the strains fell into three well-defined groups characterised by their ability to kill varieties carrying either the gene Nx or the gene Nb, the gene Nx only or the gene Nb only. Two strains were encountered which bring into action the gene Nx with lethal effect and the gene Nb with a necrotic but non-lethal effect, whilst three strains were so aberrant as to be temporarily unclassifiable. U.S. seedling 41956 was effectively immune from all the strains. A genetical approach to the problem of the nature of this immunity was made from which the data accord well with the hypothesis that the character is controlled by two dominant genes with complementary effect. Together these two genes override the Nx gene, but when separated the latter expresses its full necrotic action in the presence of an appropriate X-virus.

Similar studies to the above were carried out with virus Y. Twelve strains were compared during the year and from the responses obtained on a selected range of potato varieties it was concluded that nine strains are variants within a single group whilst three appear to be distinct from these and from each other. The genetics of response to virus Y were explored in seedling progenies derived from *Solanum Rybinii* (C.P.C. 979), and necrosis-reacting seedlings and also in seedlings of complex parentage involving *S. brevimucronatum*,

S. jujuyense, *S. Rybinii* (C.P.C. 1311), *S. saltense*, and *S. simplicifolium*. The main points of interest arising from this work were found in the occurrence of exceptionally promising field-immune types in some progenies and in the evidence obtained that the genetic factors controlling necrotic responses to viruses X, A, Y, and C in these diploid species are contained within a single linkage group.

The stunting disease of potatoes recorded in 1952 is the subject of an Occasional Paper on pages 37-40. Although more infected plants have been found in Majestic seed stocks there is no indication that the disease is widespread or of serious significance. It is of interest, nevertheless, as a " new " disease and also because of its resemblance to the American unmottled curly dwarf disease. Recent studies, however, have revealed sufficient distinguishing features to disassociate the two, in name at least, and it is proposed to refer to the British disease as *Potato Stunt*.

With the co-operation of a Perthshire member of the Society the effect of environment on the spread of virus X is being followed in three commercial stocks of Majestic, all of which were derived from a common parental stock in 1950 and had a uniform virus content of approximately 0.9 per cent when sampled individually in July 1951. When sampled again in July 1952 the virus contents were found to be 2.1 per cent, 2.4 per cent, and 11.1 per cent respectively. Consideration of the circumstances under which the three stocks were grown leads to the view that the two lower values are representative of the accumulation of virus X by plant to plant spread within the crop, whereas the high value was due largely to the imposition upon this of an influx of virus from an adjacent though non-contiguous crop with a high virus content.

Root Crops and Other Brassicas

Swedes

Attention was directed mainly to the testing of samples of swedes which had been produced by various methods of breeding, in order to determine their relative worth and also decide, if possible, the method most likely to conserve the vigour of a strain. There were four trials in which the same

three varieties were used as standards, and the experimental samples were grouped for various purposes.

Winter Hardiness.—At present there are two groups of material considered to possess good winter hardiness. One is the Station strain AFT, a purple-top of good yielding capacity, and the other consists of lines derived from cross ANI, which have attracted attention in recent years for their exceptionally high percentages of dry matter. Samples of the main stock and two lines of AFT, and of two lines of ANI were tested in the winter hardiness trial. In February the percentage of sound roots in these five units ranged from 78 to 91 per cent, which compared well with 71 per cent shown by the hardy control Aberdeenshire swede, and was better than the main crop Champion with 55 and the early type Victory with 32 per cent sound. Dry-matter tests had been carried out on half-plots in November. The standard for yield of dry matter was then set by Victory with 64 cwt. per acre. The three AFT samples averaged 64, one giving 66 cwt., but the ANI samples yielded 61 and 59 cwt. The lower yields of ANI were due to small size of root, for they had 12.6 and 13.1 per cent of dry matter compared with 11.8 for the Aberdeen, 11.2 for the AFT samples, and only 10.2 per cent for Victory. The main stock of AFT was sown out in three other trials, the following relative yields of dry matter being obtained :—

Trial	*AFT*	*Victory*	*Champion*	*Aberdeenshire*
52/1	100	90	97	70
52/2	100	88	96	73
52/4	100	93	94	80

Trial 52/1 was lifted in October, 52/2 in December, and 52/4 about the end of October.

Breeding Groups.—In trial 52/4 eight Station strains of swede and the usual three controls were compared. With one exception the plant stands were all over 90 per cent when 100 is a full stand at 10 in. spacing. The mean yield of dry matter for the whole trial was 66.5 cwt. per acre, and AFT headed the list with 73 cwt., being above average in both yield and percentage of dry matter. Strain APZ, a shapely globe purple-top of recent origin, stood second with 72 cwt., being average in yield and high in percentage, and then came AOE with 70 cwt. and AMN with 69 cwt. Both of these are early types which have been extensively selected, and the

particular sample of AOE (Boghall selection) was the best in a trial described below. Champion with 69 cwt. and Victory with 68 cwt. were above the mean and the other four Station strains fell short of it. These included a pedigree line selected from Champion, two selections from a group, AOG, under examination for clubroot resistance, and AGZ, an older strain.

Selection within Groups.—Two trials, each containing the three controls, a sample of strain AFT, and twenty-one experimental samples were used for comparing groups of related lines. The most comprehensive of these groups was contained in trial 52/1 and is summarised in the following table :—

Trial 52/1	Number of Units	Percentage of Full Stand	Dry Matter per Acre in Cwt.	Root Yield per Acre in Cwt.	Dry matter Percentage
Controls					
Victory .	1	98	57	531	10.7
Champion .	1	94	62	519	11.9
Aberdeen .	1	99	44	351	12.6
Reciprocals					
AOF . .	4	95	56	509	11.0
AOE . .	16	94	58	550	10.6
AOE Sections					
(1) P.B.S. .	2	95	57	510	11.2
(2) Boghall .	1	97	67	612	10.9
Auldhame	4	94	58	542	10.7
Dale .	9	94	57	555	10.3

AOE and AOF were reciprocal crossings between a line of Dreadnought swede and a strain, ABJ, obtained by hybridising swede × turnip and crossing back to swede. Both parent stocks were heavy croppers with low dry-matter percentages, but Dreadnought had an intermediate root shape and light purple skin, while ABJ was spherical and dark purple. A few lines were bred from AOF by self-fertilised selections. They looked promising in 1950, but four progenies in the present trial were all below average for yield of dry matter and compared unfavourably with the mean of the sixteen AOE units. The F_1 hybrid generation of AOE was mass multiplied to give a large amount of seed, and this was sown in large plots at the

Plant Breeding Station and a field strip on a coastal farm near North Berwick belonging to Mr J. R. Dale. A large number of selections was made at the Station on the basis of dry matter and root weight. They were reselected in 1950 and two units marked " P.B.S." were included in the trial. These, like AOF, tended to be relatively high in dry-matter percentage and low in yield. The second group of fifty plants was selected to conform with Mr Dale's ideal type, and plenty of seed was obtained. Part of this was sown in a field strip at Boghall experimental farm in 1950, from which fifty good, spherical roots were chosen and seeded in isolation. Their progeny, marked " Boghall," gave the best yield of this trial, and the same sample was well placed in trial 52/4 mentioned above. Another portion of seed was sown out for a second time at Mr Dale's farm, Auldhame, and ten plants were kept and self-fertilised, four of the progenies being included in this trial as " Auldhame." Some of these were very heavy yielding, but selection had this time favoured the long shape and light skin colour of the Dreadnought ancestor, and they looked quite distinct from most of the lines, which were dark or light purple globes. Finally there were observation plots and a field trial at Corstorphine, and various selections were made, some of which were seeded in groups and others separately in bags. Nine progenies, marked " Dale," were very variable in individual merit, but on the whole tended to have low dry-matter percentages with or without the compensation of a heavy yield. No difference of any significance could be found between those units which had been self-fertilised and those that were seeded in groups, and no attempt has been made to separate these in the table.

F_1 Hybrids and Parent Lines.—Supplies of seed obtained from hand crossings of swedes grown in the greenhouse and from selfings of the parent plants are usually too scanty to sow more than a short drill or two, and when the F_1 hybrids and parent lines are sown out together, it is difficult to get comparable plant stands. In about half a dozen such comparisons, where results were not invalidated by disparity in plant numbers, the hybrid exceeded the mean of the two parents in root weight and yield of dry matter but was usually slightly below that average for percentage of dry matter.

Clubroot Tests.—Various samples of Asiatic brassicas and groups of swede progenies from resistant parents were tested

in boxes of infected soil, using Bruce turnip and Giant rape as extremes of comparison. All the Asiatic material examined proved to be highly susceptible to clubroot. It was also noted that some of the swede lines, which appeared to suffer very little harm from the disease, bore numerous small nodules at the base of the side roots. These nodules do not appear to enlarge, and a similar condition is frequently found in the resistant variety Wilhelmsburger.

Kales

Greater attention is now being given to leafy forms of *Brassica* to see whether new types can be bred which would either improve the efficiency of crops such as kales and rape, or extend the periods during the year when green fodder could be made available. A new series of hybridisations between forms of *Brassica oleracea* was carried out in 1952, and a collection of cultivated varieties of Asiatic Brassicas was examined, while trials with the older breeding material were continued.

Kale Crossing.—The marrow-stem kale is nowadays frequently grown for its leafage, but it was originally bred for its stem, and leafier forms might have been obtained had the criterion been different. A number of crossings were made between plants of different varieties of kohl rabi and thousand-headed kale, while curly kale and one of the large-leaf forms of broccoli were also used as parents. Attempts to combine kale and turnip were also continued.

Asiatic Brassicas.—The reasons for examining this group of plants are discussed in an Occasional Paper at the end of this report. Twenty-nine samples of *Brassica pekinensis*, *B. chinensis*, and *B. japonica* were received from Japan and U.S.A. Small plots were sown out on different dates in 1952, and plants were also started in boxes and transplanted. Bolting occurred in all the sowings but the varieties showed differences in susceptibility, and *B. japonica* seemed less affected than the other species. *B. pekinensis*, the Chinese cabbage, had many distinct varieties of lettuce-like forms, some of which gave heavy crops.

Hybrid Kale Trials.—For a long period the Station maintained a few strains which had at first given good yields, but

in later generations lost vigour through inbreeding, though they still possessed desirable characters. In recent years fresh crossings have been made and examined with a view to devising methods of maintaining vigour in hybrid strains. As in 1951, the trials were of two sorts, unthinned rows of plants sown *in situ*, and widely spaced plants transferred from a seed bed. The yield of leaf and stem was found for a measured length of drill in the former and for individual plants in the latter type of trial. An unthinned trial was discussed in the 1952 report, and the results obtained this year were very similar. Some figures have been extracted from the transplanted kale trial and are given in the table.

Transplant Kale Trial	1st Cutting		2nd Cutting		Percentage Loss or Gain	
	Leaf oz.	Stem oz.	Leaf oz.	Stem oz.	Leaf	Stem
ASX′ . . .	42	12	36	15	−14	+26
ASX″ . . .	41	12	29	13	−30	+ 6
Thousand-headed .	37	11	33	11	−11	+ 6
Marrow-stem . .	34	24	27	28	−22	+15
N.Z. Hybrid . .	34	26	27	29	−19	+15
AMKbaBA . .	33	7	31	8	− 4	+12
AMKbaAA . .	32	9	28	9	−13	+ 1
ASW′ . . .	27	9	23	11	−16	+20

Weighings were made at weekly intervals, some plants of each plot of a block being cut at one time. A first series of half-plots was cut, block by block, between mid-September and mid-November, when a severe frost occurred, and the second series of half-plots were taken from after the frost till mid-January. One object of the trial was to observe what loss of leaf and gain of stem weight occurred during the winter. It will be seen that marrow-stem kale lost more leaf and gained more in stem weight than thousand-headed kale, the latter being noted for its ability to maintain a good supply of leafage throughout the winter. It was thought in 1951 that the New Zealand " Hybrid Kale " strain held its leaves better than ordinary marrow-stem kale, but this year they were very alike

here, though the New Zealand strain was more leafy in the unthinned trial. At the top of the table there are two first-generation hybrids, ASX, obtained by isolating two completely unrelated plants, one from the AMK strain of thousand-headed kale × broccoli and the other from a perpetual × curly kale strain. It will be seen that the yield of leaf was good, but that there was rather more stem than in thousand-head. At the foot of the table there is another first-generation cross, ASW, obtained by isolating two plants of the perpetual × curly kale material, which were to some degree related, and there was little sign of hybrid vigour in this case. Two samples of the inbred AMK, thousand-headed kale × broccoli, still showed the high ratio of leaf to stem, but were low yielding. It is hoped to restore vigour by intercrossing with unrelated strains which may be derived from the new hybridisations.

Sugar Beet

The research programme with sugar beet has been undertaken at the request of the Sugar Beet Research and Education Committee of Great Britain, and it is mainly concerned with the problem of the elimination of bolting from crops in the northern parts of the beet-growing area. This is desirable for two reasons: (1) bolted plants impair the efficiency of mechanical harvesting as well as lowering the sugar yield of the crop; and (2) if sugar-beet strains possessed high resistance to bolting, earlier sowing might be practised when weather conditions were favourable. Mid-April is taken as the normal sowing date for sugar beet in Scotland, and even then some degree of bolting may follow. For every week the sowing date is advanced the risks increase, although, as will be apparent from the experiment described below, early April sowings may escape in some years. Suitable weather for sowing is a still more uncertain factor. In some years, of which 1951 was an instance, the land is not fit for cultivation before early April, while in more extreme cases, like 1947, it may be hardly workable before May; but usually there are dry spells to be found in March or the first half of April, when beet could be sown if it was worth while.

A trial was designed to compare two strains of sugar beet when sown on three dates in the spring of 1952. The strains

were Klein E, a variety widely grown in Scotland, and KNB 178, an experimental, non-bolting strain bred by the Cambridge Plant Breeding Institute, and there were seven or eight hundred plants in each sowing. Counts of bolters were made each week from 24th June to 17th September, but for conciseness only records of every third week are given in the table.

Sowing Date	March 11		April 3		April 16	
Strain	Klein E	KNB 178	Klein E	KNB 178	Klein E	KNB 178
Percentage of Bolters on :—						
June 24 .	5.6	0.0	0.1	0.0	0.1	0.0
July 17 .	16.7	0.1	0.7	0.0	0.6	0.0
August 6 .	21.8	0.3	1.3	0.0	1.0	0.0
August 28 .	27.8	1.1	2.2	0.0	1.6	0.0
September 17	30.6	2.3	2.6	0.3	1.7	0.0

It will be seen that in the first sowing, which was made on 11th March, 6 per cent of the plants of Klein E had commenced to bolt by the end of June and another 11 per cent started during the first half of July. Thereafter the increase was not so rapid, but 31 per cent in all had bolted by 17th September. Under similar conditions of March sowing, the first plant to bolt in strain KNB 178 was found on 17th July, and only 2.3 per cent had appeared by mid-September. The really critical date for sowing was 3rd April, for growers might sow considerable areas in early April if it were not for uncertainty as to bolting. In 1952, however, the behaviour was almost the same as that of the mid-April sowing. In both cases Klein E had a few early bolters and other plants started later to raise the numbers to 2 or 3 per cent, while in strain KNB 178 there was no bolting at all except for two plants in the 3rd April sowing which were first recorded as bolters on 4th September. Thus the Cambridge non-bolting strain behaved in a satisfactory manner throughout, though the weather for sowing in April made little demand on its special qualities. The trial was also fully tested for yield and sugar content, but a series of tests in different years are required before any generalisations can be made, and a trial of the same sort has been sown out on various dates this spring.

Trials of Non-bolting Material.—The main trial of 1952 consisted of twenty-five samples of sugar beet arranged in two sub-trials, one of which was sown early, on 19th March, and the other at the normal time, on 11th-12th April. The bolting in this second part was very slight, a few plants bolting, mostly late in the season, in the controls, and single plants in four of the experimental lines. In the mid-March sowing, two varieties not specifically bred for resistance to bolting had 20 and 36 per cent of their plants bolted by mid-September, while the third control, the German non-bolting variety, Klein AA, had only 3 per cent. Most of the units in the trial belonged to the Cambridge non-bolting material. Three samples of KNB 178, mentioned above in the special trial, averaged only 1 per cent and some other Cambridge families were almost as good, while no sample in this series exceeded 10 per cent. There were a few samples of the Station "Logie" material in this trial, but most of these were in another trial with only one sowing date, 20th March. The Logie families, which have not yet been subjected to light treatment, were more variable. An object of both trials was to compare "line" and "polycross" samples of the different families. The line sample was obtained by seeding a single family in isolation, while the polycross seed was borne on plants of a family growing among flowering plants of other families. The line and polycross samples of Logie material were very alike in bolting behaviour, but the Cambridge polycross samples tended to be slightly more bolted than their respective lines. Sugar and yield determinations were made on both parts of the trial containing the Cambridge material, but the plant numbers of the Logie trial were too erratic for yield comparisons.

"Round" Sugar Beet.—When the Society was asked to undertake work on the breeding of sugar beet in 1947, there was considerable demand from growers for a beet that could be easily lifted, and it was frequently asked whether a spherical or globular shape could not be incorporated into an efficient sugar-beet plant. Since then mechanical lifting has become widely practised in Scotland and the orthodox deep-set root is most suitable for the machines, so that there is no longer much interest in the possibility of creating a round sugar beet. Some small breeding experiments had reached a stage at which it was considered that some observations would be

of interest, and a small trial was laid out in 1952. The figures extracted for the adjoining table are mostly averages, for though there was only one sample of table beet there were four of sugar beet. Seven progenies of hybrid, sugar beet × red beet, mother plants are included in the F_2, and nine progenies of male-sterile sugar beet pollinated by the hybrids comprise the back-cross.

The date of sowing, 28th April, though late for sugar beet, was still too early for table beet, which had 16 per cent of bolters while the hybrids were intermediate with 10 per cent.

	Percentage of Bolters	Percentage Dry Matter	Percentage of Sugar	Weight per Root in lb.
Sugar Beet .	1.3	24.7	16.7	1.4
Table Beet .	15.9	15.1	9.7	1.2
Sugar × Red F_2	9.6	19.8	12.6	1.5
Sugar × Hybrid Back-cross .	10.9	22.5	15.0	1.4

The F_2 hybrids were intermediate in percentages of both dry matter and sugar, while the back-crosses gave somewhat higher values. The F_2 hybrid plants segregated approximately in the proportions of three red to one white, and the back-crosses gave a 1 : 1 ratio, but in both groups a few plants with orange or yellow skin occurred. Shapely roots of both red and white F_2 segregates were weighed and tested for solids in the juice. The white roots appeared to have firmer flesh, and the tests showed the following mean values :—

	White Roots	*Red Roots*
Total Solids in Juice .	17.53 ± 0.246	15.38 ± 0.194 per cent
Root + Crown Weight	33.0 ± 1.59	35.55 ± 0.66 oz.

Selection.—Roots of some Cambridge families and Logie lines were selected and stored in pits which were opened in March when most of the roots were found to be in good condition, though one or two lots were damaged by frost. The roots were planted out in isolation plots. Three groups of hybrid sugar beet × table beet derivatives were also selected, pitted, and planted out.

Propagation.—Twenty-one plots of various sizes were arranged in the neighbourhood of Edinburgh for the isolation of sugar beet. The roots were in fair condition when planted out, and the harvest was better than in the previous two years, but not completely satisfactory. The seed from some plots gave fair percentages for germination, but in other cases it was very low. The seed yields and germination percentages obtained during the last four years were studied to assess how successfully seed production in the open can be carried out in Scotland. It was concluded that strains could be maintained, but that the condition of the seed was not generally good enough to compete in yield trials with commercial strains.

J. W. GREGOR, *Director.*
R. J. L. GALLIE, *Secretary.*

APPENDIX

Acknowledgments

Grateful acknowledgment is made to the undernoted departments, institutes, firms, and individuals for facilities for carrying out experiments and for gifts of samples or other material :—

Agricultural Research Council, Potato Genetics Station-Cambridge (per K. S. Dodds and M. A. Keay).
Alexander, Robert F., Boyne, Inchture.
Allison, A. W., Turnhouse Farm, Corstorphine, Edinburgh.
Allison, William, Almond Hill, Kirkliston.
Bazan de Segura, C., La Molina, Lima, Peru.
Bell, David, Ltd., 15 Coburg Street, Leith, Edinburgh.
British Sugar Corporation, Ltd., Cupar.
Carmichael, J. R., Carlunan Farm, Inveraray.
Department of Agriculture for Scotland (per Director and Members of Staff, East Craigs, Corstorphine, Edinburgh).
Edinburgh and East of Scotland College of Agriculture (per Dr A. M. Smith and Farm Managers).
Dods, William, & Son, Haddington.
Duncan, G. F., Waterton, Elgin.
Farmers' Supply Association of Scotland, Ltd., 9 Wellington Place, Leith, Edinburgh.
Gibb, Lt.-Col. Jocelyn E., Keppoch Farm, Dundonnell.
Gray, G. B. R., East Fenton, Drem.
Mackay, H., Kintraw Farm, Barbreck, Argyll.
Mackintosh, C., Easter Duthil, Carrbridge.
Marshall, John, Dalreoch, Dunning.
Mastenbroek, C., Veredelingsbedrijf, Centraal Bureau, Hoofdorp, Holland.
Mills, Fred. (Roughead & Park, Ltd.), Haddington.
Mitchell, William, West Loch, Eddleston.
National Institute of Agricultural Botany, Huntingdon Road, Cambridge (per Director, Members of Staff, and K. O. Müller).
Nattrass, R. M., Scott Agricultural Laboratories, Nairobi, Kenya.
North Coombes, A., Department of Agriculture, Reduit, Mauritius.
Pest Control (United Kingdom), Ltd., Bourn, Cambridge.
Plank, J. E. van der, Department of Plant Pathology, Pretoria, South Africa.

Plant Breeding Institute, Cambridge.
Rigot, N., Ministère de l'Agriculture, Libramont, Belgium.
Roberts, Sir James Denby, Bt., Strathallan Castle, Auchterarder.
Rothwell, A., Branch of Botany and Plant Pathology, Department of Agriculture, Causeway, Southern Rhodesia.
Serenbach, Rev. Campbell, 68 Kirk Brae, Edinburgh 9.
Scottish Agricultural Industries, Ltd., 35 Charlotte Street, Leith, Edinburgh.
Smith, W., & Son, Ltd., 18 Market Street, Aberdeen.
Stewart, Mrs Shaw, Traigh House, Arisaig.
Sword, J. C. (S.C.W.S., Ltd.), Glasgow.
Toxopeus, H. J., Instituut voor Veredeling van Landbouwgewassen, Wageningen, Holland.
Young, James, West Craigs, Corstorphine, Edinburgh.

Publications

Black, W. "A Genetical Basis for the Classification of Strains of *Phytophthora infestans*." *Proc. Roy. Soc.*, Edinburgh, B. LXV., pp. 36-51, 1952.

The inter-relationships of ten strains of blight (*Phytophthora infestans*) and four major genes, R_1, R_2, R_3 and R_4, controlling resistance to the disease in potato foliage are examined. The complete differential host series for this material numbers sixteen, and is capable of differentiating sixteen strains of the pathogen. The reactions exhibited by the series form a concise statement of the various relationships and provide a genetical basis for the systematic classification of strains. This classification affords a means of calculating the segregation-ratios to be expected from the mating of any pair of genotypes when infected with any strain or group of strains of the parasite.

Each strain, being adapted to a particular *Solanum* genotype, is more prolific on it than on any other. This genotype is regarded as the natural host of the strain in question. Specialisation of the parasite appears to progress in stages in certain directions determined by the genetic constitution of the various hosts.

Black, W. "Recent Research in Potato Breeding for Blight Resistance." *British Agricultural Bulletin*, Vol. 5, No. 19, pp. 15-18, 1952.

A review of investigations on resistance to blight (*Phytophthora infestans*) in potatoes with special reference to the

mode of inheritance of the genes controlling hypersensitivity in the host and to the problem of specialisation in the parasite.

Black, W. (with K. O. Müller). "Potato Breeding for Resistance to Blight and Virus Diseases during the last Hundred Years." *Zeitschr. f. Pflanzenzücht.*, Band 31, Heft 3, pp. 305-318, 1952.

An historical survey of the major factors which have determined the course of potato breeding during the past century. It is based upon the progress made in the search for blight and virus-resistant varieties since the time of the great potato famine in Western Europe.

Cameron, D. "Agronomic Characteristics of Oat Varieties." *Chemistry and Industry*, 1953, pp. 117-118.

A review of varietal attributes in relation to utilisation in which "Agronomic characteristics" are defined as those characteristics of a variety which influence the farmer in making his choice of variety for his own particular requirements, and in which those aspects of particular interest to the plant breeder are discussed.

Differences are recognised between varieties in length and strength of straw and ability to withstand adverse weather conditions, in the ability to produce a satisfactory crop under abnormal or extreme conditions, in yielding capacity of grain and straw, in the time taken to reach maturity, in the size, shape and colour of the grain, and in many other respects. Some of these aspects are discussed in relation to the utilisation of the varieties and it is pointed out that with changing conditions Sandy is giving place to Bell and Yielder, and Potato to Onward, Victory, &c., the trend being more and more towards grain-producing types. Mention is made of the special-purpose types Craigs Afterlea and Albyn Donside recently introduced by the Plant Breeding Station, and their place in the agronomic environment.

Cockerham, G. "Breeding for Resistance to Potato Viruses." *Proc. Conf. Potato Virus Diseases, Wageningen-Lisse* 1951, pp. 37-39, 1952.

A condensed account of the genetical background to breeding for virus resistance, especially for field immunity, in the potato.

OCCASIONAL PAPERS

Potato Stunt Disease

G. Cockerham and T. Mairi R. McGhee

The stunting disease of potatoes described below was brought to our attention in August 1949. It was encountered in a Perthshire seed stock of the potato variety Majestic, from which three further specimens, all in the early stages of infection, were obtained in subsequent years. These are, however, the only records of its occurrence and it would seem that although the disease is severe in its effects it is limited in its distribution and of little economic significance.

Experimentally the disease has been studied from various aspects and it is now clear that the causal agent is a virus which is transmissible by stem grafts and by sap inoculation. Both methods of transfer have been used to infect potato varieties and solanaceous species with the following results.

The potato varieties Aquila, Arran Banner, Arran Peak, Arran Pilot, Arran Victory, Ballydoon, Cherokee, Craigs Alliance, Duke of York, Dunbar Rover, Dunbar Standard, Early Rose, Epicure, Gladstone, Great Scot, Green Mountain, Imperia, Irish Chieftain, Irish Cobbler, Kerr's Pink, Majestic, Ontario, Saskia, and Sirtema when infected by stem grafts all respond in similar fashion. The disease becomes manifest with the appearance of grey-black, soaked necrotic lesions upon the lower leaves of the young axillary shoots or of the grafted stem itself. The lesions take the form of spots, rings, or irregular patches which enlarge rapidly and coalesce to fill much of the interveinal areas (Plate I., *Fig.* 1). Subsequently these areas collapse and the leaf wilts and falls. The sequence is repeated on leaves in acropetal succession, but as the disease advances upwards the necrotic effects diminish and leaf fall is halted before reaching the stem apex. At this stage affected stems present a " palm tree " appearance with a large or small crown according to the extent of the leaf fall (Plate I., *Fig.* 2).

As the general necrosis approaches the crown the upper leaves assume a chlorotic appearance and roll inwardly to show a flush of colour—red, blue, or yellow according to variety—on their exposed under-surfaces. Necroses are frequently scattered within the interveinal areas and around

the leaflet edges, causing the tips and margins to wither. The leaves are hard and brittle.

From the onset of rolling, which completes the primary phase of the disease, growth is retarded and may cease completely. Any new extension growth which may be produced, however, shows the secondary symptoms of stunting with short internodes and a reduction in the size of leaves which may also be considerably malformed.

Infected tubers, whether from plants still in the primary phase of the disease at harvest or from later generations, are invariably slow to sprout but they are nevertheless fully viable and plants emerging from them appear at first to be exceptionally strong and healthy with flat, turgid leaves of an intense green colour. Symptoms of their infection gradually develop, however, and ultimately the full disease becomes evident. In detail the symptoms of this disease vary from plant to plant, even within a single variety, but an erect, stunted habit is characteristic in all cases. Usually the leaves are turgid, chlorotic, rolled and discoloured with varying amounts of interveinal necrosis ranging from minute flecks to large irregular patches. Additionally, but not invariably, leaves are malformed through incomplete differentiation of the leaflets which remain "tied" at their margins. This condition is frequently associated with thickened veins and distorted petioles (Plate I., *Fig.* 3). There is also a general tendency towards an alteration in the size relationships between leaflets and folioles, so that some leaves appear to have more than their full complement of the former. In the variety Duke of York this tendency has occasionally been so marked that affected plants have had the semblance of a "multiple leaf" variation (1).

The potato varieties Ackersegen, British Queen, Di Vernon, and seedling 835(*a*)4 respond to infection in slightly different fashion from the main group of varieties. They show typical foliar necrosis with acropetal leaf drop during the early stages, but there are no subsequent leaf-rolling symptoms and the leaves which develop after infection is established are thick, rugose, occasionally chlorotic and necrotic, and very frequently malformed. Extension growth is always severely stunted, as are the whole plants in the year following infection.

The American seedling U.S.41956 often shows neither necrosis nor leaf rolling but may pass into the full secondary

EXPLANATION OF PLATES I. AND II.

PLATE I.

FIG. 1. Leaf of the potato variety Dunbar Standard showing necrotic collapse of interveinal tissue prior to leaf drop.

FIG. 2. Plant of the potato variety Epicure in which the intermediate leaves have dropped to give a " palm tree " stem.

FIG. 3. Young plant of the potato variety Majestic grown from an infected tuber. The plant is erect in habit and bears dark-green, malformed leaves which are beginning to roll inwardly.

FIG. 4. Plant of the potato variety U.S.41956 showing stunted growth and malformed leaves twelve weeks after infection by graft.

FIG. 5. Localised necrosis on inoculated leaf of the potato variety Majestic nineteen days after rubbing with sap from infected tobacco leaves.

PLATE II.

FIG. 1. Potato stunt disease in the field. Healthy plants in the background.

FIG. 2. A typical stunted plant of the potato variety Majestic.

PLATE I.

PLATE II.

phase of infection within a few weeks from grafting. The new growth is stunted and bears leaves which are grey-green in colour, coarse in texture, and markedly puckered in the interveinal areas. All the leaves are malformed with thick, distorted veins, and they have a marked tendency to curl downwards at the tip (Plate I., *Fig.* 4).

A few tubers of many of the above varieties have been planted in the open. In every case they germinated tardily to produce dark-green, apparently healthy plants which, like their counterparts under glass, later developed the full symptoms of disease appropriate to the variety. Stunting was always very severe and the fully grown plants, though erect, rarely exceeded eight inches in height (Plate II., *Figs.* 1 and 2).

Infection of potato varieties by sap inoculation, using the leaf-rubbing method with carborundum powder as an abrasive, has been accomplished successfully on many occasions. On only two of these occasions, however, has systemic penetration taken place with the production of the full symptoms of disease. More usually the infection is confined to the inoculated leaf either in the form of large but restricted necrotic lesions or as a more general necrosis of the whole leaf, which withers and dies before infection has passed into the stem (Plate I., *Fig.* 5).

Solanaceous species which have been infected are *Nicotiana rustica* and *Lycopersicum esculentum* var. Essex Wonder, which show no symptoms ; *Solanum demissum* and *S. nodiflorum* which respond with an initial necrosis followed by a general chlorosis with stunting and distortion of the new growth developed after infection is established ; and *Capsicum frutescens*, *Physalis floridana*, and *N. tabacum* var. White Burley, which become chlorotic, stunted, and distorted.

In an earlier reference (2) to this stunting disease of potatoes it was stated that the disease had been tentatively diagnosed as unmottled curly dwarf, a virus disease described in the U.S.A. by Schultz and Folsom (5, 6) and later by Goss (4) and Folsom (3). The two diseases are, in fact, closely similar in many respects and it may be that the causal viruses are related. There are several lines of evidence which suggest, however, that they are not identical. For example, the hallmark of the primary phase of infection with the Scottish virus is the strong necrotic response and acropetal leaf drop. In the American disease, on the other hand, necrosis is not a

marked feature of infection. Also, the American disease is reported to be transmitted readily by various insect vectors, whereas all attempts to transmit the Scottish virus in this way have failed. Until the two viruses have been compared directly, therefore, and in order to avoid possible confusion it is proposed to refer to the Scottish disease as potato stunt and to its causal agent as the potato stunt virus.

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The Domestication of Brassica

By V. E. McM. Davey

The genus *Brassica* has been the source of many valuable forms of plants used in cultivation ; and, in one instance or another, practically every organ has become modified and developed to provide human food or cattle fodder. Thus the leaf, bud, petiole, stem, or root may each in its turn be prized as a foodstuff, perhaps in a more or less natural state but more probably when modified to a disproportionately large and highly nutritious storage organ. Though the fruit may appear less subject to change, oils or condiments may be obtained from the seed, while the cauliflower is unique in converting a developing inflorescence into a fibreless "curd."

It may be supposed that some at least of the horticultural and agricultural forms of *Brassica* have reached such a high state of breeding that little further improvement is possible by direct means. Indirectly, perhaps, the efficiency of a variety may still be substantially improved by introducing

disease resistance, by obtaining tolerance to a wider range of environmental conditions, or even by making some radical change in the method of propagation. Apart from makeshifts such as these, however, there is always the possibility that this most versatile genus may be induced to produce yet more new forms. Most of the *Brassica* crop-plants cultivated in Europe have been in existence since antiquity, though only in the last century or two have selection and breeding produced the high quality and heavy yield which is now expected of varieties. One case in which the origin of a form has been recent, however, is that of marrow-stem kale, which was obtained in the nineteenth century by hybridising two older forms of *Brassica oleracea*, the kohl rabi, and the thousand-headed kale. It is noteworthy that marrow-stem kale serves purposes which differ from those to which its parents are put, so that the creation of a new form has led to a development in agricultural practice. Much work has been done with hybridisations of Brassicas, especially within the cabbage tribe, but though many striking recombinations of characters have been obtained, few have been satisfactory, for it is not easy to recover the highly developed qualities of the parents in details such as smoothness of skin or freedom from fibre.

The cytological investigations of the last thirty years have thrown light upon the relationships of *Brassica* species, and suggested new lines of approach. The species to which the cultivated forms are attributed, and for which there may or may not be a wild form known, fall into a relatively simple scheme, which was first propounded by some Japanese plant breeders, and subsequently confirmed and amplified in Britain and Scandinavia. According to this there are three groups at the lowest level, containing one genome each, "a", "b" and "c", and there are three amphi-diploid groups containing two genomes each, viz. "ab", "ac" and "bc". These combinations have recently been obtained experimentally, and indeed K. J. Frandsen has carried the synthesis a stage further by breeding plants with all three genomes, "abc". Genome "a" is a hereditary constitution with N = 10 chromosomes, and there are two important groups of cultivated forms possessing this number. Firstly *B. Rapa* L. (sometimes called *B. campestris*), which embraces both yellow and white-fleshed forms of the common turnip, and a series of turnip-like rapes grown for oil on the Continent, and known in Britain chiefly

as " bird-seed rape." The other group occurs in Asia, where there are a number of 10-chromosome species, which provide important horticultural forms, viz. *B. pekinensis*, Rupr., the Chinese cabbage, *B. chinensis* L., the Chinese mustard, and *B. japonica* Sieb., another so-called mustard. Genome " b " has a constitution of N = 8 chromosomes and is represented by *B. nigra*, the brown mustard from which the condiment is prepared, while genome " c ", with N = 9 chromosomes, is found in *B. oleracea* L., *B. albaglabra* Bailey, and some island species. *B. oleracea* includes all the well-known vegetables of the " cabbage tribe " and various kales. The combination of genomes " ab " has N = 18 chromosomes and is found in *B. juncea* Coss, the Indian mustard, and *B. cernua* Hemsl. Genomes " bc " give a plant with N = 17 chromosomes, which characterises another mustard from Abyssinia, *B. carinata* Braun. The combination " ac " with N = 19 chromosomes is of chief interest in Europe, for this is the constitution of *B. Napus* L. (Peterm.), which includes the swede, annual and biennial rapes used for oil and fodder, and some kales.

It has already been shown by Howard, K. J. Frandsen, and others that the combination of genomes can be effected experimentally. It is possible that valuable forms may be obtained in this way, if not directly at least by hybridising the artificial combination with the established form of supposedly similar constitution. The most likely constitution for European agriculture would appear to be the " ac " combination, *B. Napus*, for which no wild species has ever been found, and which may be of recent origin in respect of the " root " bearing swede, which has only been known for a few centuries. A possible parent to provide the " c " genome could be some member of the cabbage tribe, though attention might also be directed to several wild species. The natural choice for the parent containing the " a " genome would be *B. Rapa* with its closely parallel series of forms, but it might also be one of the Far-Eastern species. In each case there is affinity between the chromosomes of the N = 10 species and some of the *B. Napus* chromosomes, but the European and Asiatic species are not completely compatible with one another.

A preliminary examination of varieties of the three Asiatic species has been undertaken at the Plant Breeding Station, with the object of looking for characters which might be

introduced from them into European crop plants. This might be effected by hybridisation directly with the relatively closely related turnip family, or indirectly by attempting to obtain a combination with some member of the cabbage tribe that might be compatible with the species *B. Napus*. From a number of samples obtained from Japan and the U.S.A., it is apparent that the Chinese cabbage, *B. pekinensis*, has numerous distinct and highly uniform varieties of lettuce-like plants, and that the Chinese mustard, *B. chinensis*, is also highly developed as a vegetable, but two obvious disadvantages were disclosed. Firstly, all three species appeared to be very susceptible to clubroot, and would therefore be unlikely to contribute resistance to this disease to a hybrid; and secondly, all the samples examined, whether *B. pekinensis*, *B. chinensis* or *B. japonica*, appeared to be very liable to a rapid bolting or running to seed, sometimes within a few weeks of sowing, if conditions were not exactly right for their vegetative development. On the credit side, however, it could be said that none of the varieties formed inedible woody stems, and that some of the Chinese cabbages, particularly the Shantung type, appeared to be capable of very heavy yields of leafage.

Responses of a Hill Vegetation to Manuring

By J. W. Gregor and Patricia J. Watson

In experimental work it is often instructive to employ extreme treatments regardless of economic considerations. For instance, no one is likely to apply annually to extensive areas of hill land superphosphates at the rate of 8 cwt. per acre, and, even less, annual dressings of 36 cwt. per acre of nitro chalk. Yet results obtained after treating hill vegetation in this generous fashion are not devoid of practical significance or unrelated to current developments. In the last few years the use of the aeroplane for distributing manures on hill land introduces interesting possibilities and is indeed rapidly becoming an economic proposition in New Zealand. It has been suggested that Scotland might with advantage follow New Zealand's lead. While the practicability of such a programme is no longer in doubt, it would be only prudent to

consider the nature, extent, and speed of vegetational responses which manuring of hill land might be expected to give before attempting to forecast the trend of future developments. The following observations have some bearing on these practical issues, though they have reference to an experiment designed for another purpose.

In this experiment a natural vegetation with Sheep's Fescue as the dominant species was subjected over a period of eight years to four manurial treatments, viz. : *I.* Over the entire eight-year period superphosphate and muriate of potash applied twice yearly at the respective annual rates of 8 cwt. and 4 cwt. per acre, and six applications of nitro chalk per annum at the rate of 6 cwt. per acre per application ; *II.* as for *I.* during the first four years, thereafter no nitrogen ; *III.* no treatment other than grazing and cutting during the first four years, thereafter superphosphate and potash at the above rates ; *IV.* as for *III.* but superphosphate only.

The lime requirement was satisfied before the start of manuring and a pH of between 6.0 and 6.5 maintained throughout the period by additional dressings given as required. No roughage was allowed to accumulate on any of the plots. Herbage samples representing a week's growth were cut by lawnmower every month from May to October, both months inclusive.

In Table I., *I.*, *II.*, *III.*, and *IV.* refer to records taken during the eighth year of treatment, while *IV.* (*a*) has reference to the fourth year of treatment *IV.* In presenting the dry-matter values the monthly yields for each treatment have been totalled and to facilitate comparisons, the largest total has been given the value of 100 and all the other treatment yields are relative to this. Fig. 1 illustrates the floristic changes resulting from treatment. The species represented in the sward were assessed by taking each month a sample of the cut herbage and separating it into its species components. After separation each fraction was oven-dried and weighed, and its contribution to the dry weight of the total sample recorded. Eighth-year records only are illustrated in Fig. 1, and to simplify the diagrams the values of the respective fescue + mat grass, smooth-stalked meadow grass, wild white clover, and moss fractions represent the average monthly contributions expressed as percentages of their treatment totals

TABLE I. Effect of Treatment upon Dry-matter Yields

Treatments	Relative Yields	Percentage Increases in Yield between Treatments
I.	100	
		156
II.	39	
		15
III.	34	
		26
IV.	27	
		42
IV. (*a*)	19	

In the autumn immediately preceding the start of treatments the vegetation of the trial area had been sampled, and at that time the fescue + mat grass fraction contributed 61 per cent of the total sample, with smooth-stalked meadow grass (barely 2 per cent) and wild white clover (trace) as minor floristic elements. During the fourth year of the experiment Sward *IV.*, which had not so far received manurial treatment, was sampled with the following result: fescue + mat grass, 46 per cent; smooth-stalked meadow grass, 8 per cent; and clover, 8 per cent. Unfortunately, the moss fractions were not taken into account at that time, so the above values are not strictly comparable with the percentages given in Fig. 1. However, by deducting the moss fractions from the eighth-year records and recalculating the percentages, comparison with the final-year figures is possible. When this is done we find that after four years of phosphate treatment the adjusted values are respectively 48, 3, and 9 per cent. It is evident from these figures that since the start of phosphate manuring little change had taken place in the floristic composition of the sward so far as these three fractions were concerned, and that the increase in yield that was obtained is essentially a reflection of the manner in which the unchanged flora has responded to treatment.

The original soil analysis had shown that the trial area was low in phosphate but reasonably satisfactory in respect of potash. As shown in Table I., treatment *IV.*, phosphate

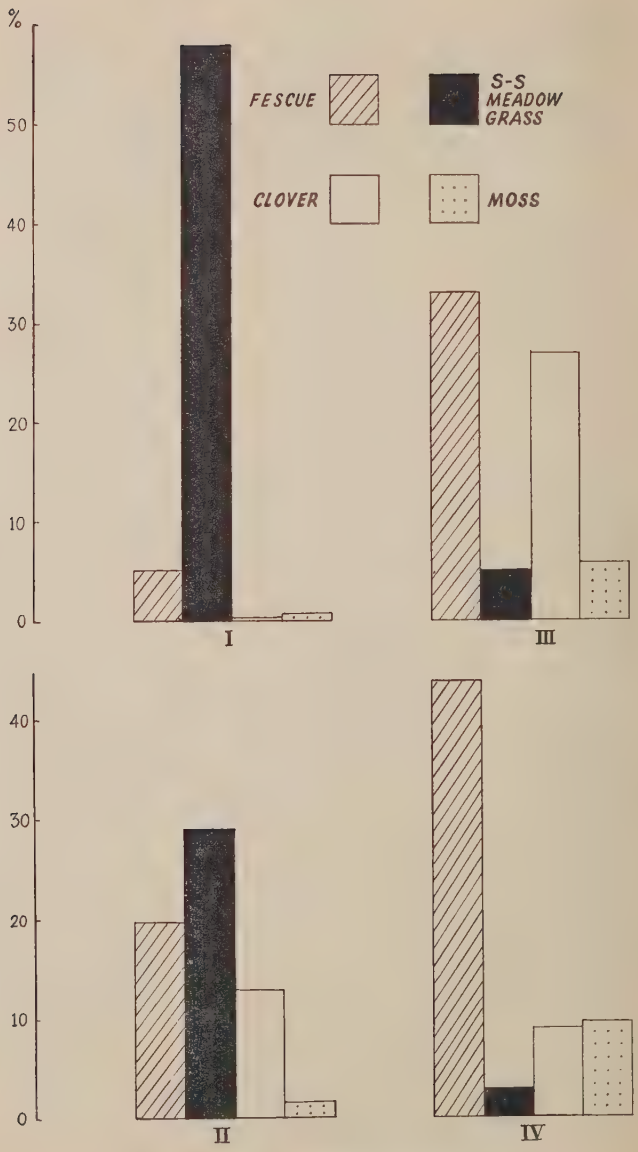

FIG. 1.—*Effect of treatment upon the flora.*

alone, raised the yield by 42 per cent. But to see this increase in proper perspective it should be emphasised that it represents only 10 per cent of the increase obtained from treatment *I.* involving the very liberal use of nitro chalk, and even this latter treatment gives a seasonal, as distinct from a peak, yield of slightly under 60 per cent of that of a similarly treated reseeded sward of early perennial ryegrass. A comparison between treatments *I.* and *IV.* shows that it is not simply a question of nitrogen stimulating the fescue to yield more highly but of the replacement of fescue by smooth-stalked meadow grass, once a very minor element in the vegetation but under the new environment a vigorous competitor. The nett result of the nitrogen treatment is an increase in dry-matter yield over phosphate alone of no less than 270 per cent.

Treatment *II.* is also informative, for the results demonstrate how very rapidly progress in the desired direction can be reversed. In the fourth year, when nitro chalk was still being applied at the rate of 36 cwt. per acre during the growing season, the yield from treatment *II.* equalled that from *I.* By the eighth year, however, the dominant position of smooth-stalked meadow grass was again challenged by fescue and yield fell spectacularly in the absence of applied nitrogen. Nevertheless, despite this relatively low yield, now only 15 per cent above that for the equivalent treatment *III.*, the sward receiving *II.* retains a very considerably higher productive potential than *III.* so far as response to nitrogen is concerned by virtue of its still comparatively high smooth-stalked meadow grass content.

In commenting on the use of manures in grassland improvement, Ellison (1) is in no doubt "that the productivity of both the natural and the reseeded areas in upland districts, as elsewhere, could be very markedly increased by the greater use of nitrogenous fertilisers." It is quite apparent from the present results that under the prevailing natural environment, and for the particular vegetation in question, nitrogen, when applied in quantity and appropriately supported by other manures, was the most potent factor in raising yields. But in this instance the striking success of nitrogen was not unrelated to the initial presence of smooth-stalked meadow grass as a community constituent. It is interesting to note, however, that Milton (2) reports that in trials conducted for sixteen years and involving two different fescue swards,

grazing and the application of a complete fertiliser resulted in the representation of smooth-stalked meadow grass being raised from nothing to 13 per cent and 27 per cent respectively, the records for the corresponding controls receiving grazing only then being 0 per cent and 3 per cent.

That it is not only the yield but also the quality of the dry matter which is affected by the liberal use of nitrogen was pointed out in a previous communication (3). If, however, the danger of a reversal of the improvement process, such as occurred under treatment *II.*, is to be minimised and both yield and quality held at their highest expressions, treatment must be continued. This is an aspect of hill-land improvement that is all too frequently overlooked as the condition of many reseeded grazings laid down in the not-very-distant past bear sad witness to-day. Some of these abandoned attempts at hill-land improvement emphasise another point which tends to be neglected when contemplating schemes of improvement by manurial or other means. In attempts to raise the output of our natural grasslands the first essential is to ensure that any expected increase in herbage production is going to serve a useful purpose. On a hill farm, where the summer rate of stocking is determined by the amount of winter feed available, there would be no object in applying manures to grazing land unless by doing so winter production could be increased. Even at the rates of manuring mentioned above, winter growth remained negligible, though in comparison with treatments *II.*, *III.*, and *IV.* the earlier spring growth obtained by the use of nitrogen did have the effect of slightly shortening the period of dormancy. Whether under the climate of Scotland the rates of application at which it would be reasonable to carry out a large-scale programme of manuring would make any material contribution even to summer production is very doubtful.

Although there is a prevalent belief that the hill grazings of Scotland are not so good as they once were, a deterioration which is attributed to the feeding habits of sheep, it is fairly certain that sheep must remain the basis of Scottish hill farming. Nevertheless, there are definite indications that the future will see a better balance between sheep and cattle, and especially between sheep and breeding cattle. The fact that it is not regular practice to hand-feed hill sheep in winter makes it a matter of no great urgency to explore novel ways

and means of providing additional winter feed for them, but a shift of emphasis in the direction of a better balance would supply the necessary incentive, for in maintaining a breeding herd of cattle the need to provide supplementary winter food is taken for granted. The incentive would be even greater if, as seems a possibility, forestry were to become established as an integral part of hill farming. In this event, the production of supplementary food on intensive lines might of necessity become every-day practice.

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